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Diet quality and its relationship with central obesity among Mexican Americans: findings from National Health and Nutrition Examination Survey (NHANES) 1999–2012

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Abstract

Objective: Using the Healthy Eating Index-2010 (HEI-2010), the present study aimed to examine diet quality and the impact of overall diet quality and its components on central obesity among Mexican-American men and women.

Design: Cross-sectional data from NHANES 1999–2012 were used. The HEI-2010 data, including twelve components for a total score of 100, were collected with a 24 h recall interview. Central obesity was defined as a waist circumference of ≥88 cm for women and ≥102 cm for men. Weighted logistic regressions were performed to assess associations between HEI-2010 scores and central obesity.

Setting: National Health and Nutrition Examination Survey (NHANES) 1999–2012.

Subjects: A total of 6847 Mexican Americans aged ≥20 years with reliable dietary recall status and non-pregnancy status.

Results: Higher HEI-2010 total score was associated with lower odds of central obesity in Mexican-American men (OR; 95 % CI = 0·98; 0·98, 1·00). Among all Mexican Americans, one-unit higher score of total fruit and sodium (i.e. lower level of intake) was associated with 4 % (0·96; 0·93, 0·99) and 2 % (0·98; 0·96, 0·99) lower odds of central obesity, respectively. However, a higher total proteins score was associated with higher odds of central obesity (1·08; 1·00, 1·16). In gender-specific analyses, a higher whole fruit or sodium score was inversely associated with central obesity in men but not in women.

Conclusions: HEI-2010 scores of total fruit and sodium were inversely associated with central obesity among all Mexican Americans. However, total proteins score and central obesity was positively associated. In Mexican-American men, HEI-2010 total and whole fruit scores were inversely associated with central obesity.

Keywords
Diet quality
Central obesity
Mexican Americans
Healthy Eating Index-2010
NHANES

Nutrition-related conditions such as central obesity have disproportionately affected Mexican Americans[1,2]. Central obesity is known as excessive waist size resulting from accumulation of abnormal fat[2,3]. Compared with overall obesity, central obesity is associated with higher risks for metabolic diseases; of these diseases, diabetes, hypertension, dyslipidaemia and insulin resistance are most prevalent in Mexican Americans[4–7].

Diet is an important lifestyle factor that has been related to body weight and composition and is critical in preventing overweight and obesity. Emerging studies are examining weight outcomes in relation to diet quality, in addition to individual food groups, specific nutrient(s) or energy intake[8,9]. Diet quality is used to evaluate the overall dietary pattern and to identify nutrition adequacy and balance[10]. One of multiple methods to measure diet quality, the Healthy Eating Index (HEI), was developed by the US Department of Agriculture based on the Dietary Guidelines for Americans[11] and has been adopted in many studies[3,12,13]. The total HEI score provides an overall measure of diet quality, while the component scores used to calculate the total HEI score offer opportunities to study

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important components of dietary intake and their health impact[3]. Previous studies have suggested inverse relationships between diet quality and risks for overall obesity, CVD and diabetes in general adult populations[14–16]. However, there is a relative shortage of knowledge on whether overall diet quality impacts central obesity among Mexican Americans.

Additionally, little is known about which components of diet quality affect body weight and composition among Mexican-American adults. Using the HEI-2005, Tande and colleagues found that a higher fruit score (all forms of fruit) was associated with 2·6 % lower odds of central obesity in women in the USA[3]. Among men, a higher score of saturated fat was associated with 3 % lower odds of central obesity[3]. The HEI-2010 made several changes according to the updated Dietary Guidelines for Americans 2010. These changes included adding a category of seafood and plant proteins to capture specific choices from the protein group, keeping whole grains and refined grains separate to assess the overconsumption of unhealthy grains, and using a ratio of PUFA + MUFA to SFA to replace oils and saturated fat to acknowledge the recommendation to replace saturated fat with mono- and polyunsaturated fat[11]. Additional research is needed to better understand the new HEI-2010 components and their relationships with central obesity. Using the HEI-2010, Drenowatz and colleagues showed that a higher sodium score, reflecting a lower intake, was associated with lower odds of overweight and obesity[16]. In contrast, a higher score of total proteins, indicating a higher intake, was associated with significantly higher odds of obesity and this association was significant in men but not in women[16]. Drenowatz *et al.*'s research was done utilizing a sample of young, college-educated people of mostly European descent[16]. There is still a lack of evidence of the effects of HEI-2010 components on central obesity among Mexican Americans, where a great proportion of individuals are of relatively low socio-economic status[17].

Previous studies indicated potential gender differences regarding diet quality and weight[18–20]. Although women are more likely to report eating 'healthier foods'[16,21], they seem to consume more sugar-laden foods than men, such as cookies, chocolate and ice cream[22,23]. Men consume a greater percentage of their energy intake from protein[22,24,25]. In addition, they tend to consume more alcohol than women[24,26]. Furthermore, there may be variations in self-report biases by gender, which could affect the association between diet quality and obesity outcomes[16,23]. Women may have a greater reporting bias, possibly due to their greater emphasis on a healthy diet than men[16,23]. Among Mexican Americans, while national data showed that the prevalence of obesity outcomes was higher in women than in men[27], regional data, in California and the Mexico–Texas border region for example, showed that Mexican-American men had the same likelihood to be overweight and obese as their female counterparts[28,29]. Mixed findings regarding the diet and obesity disparities between Mexican-American men and women indicate a need for further investigation.

Taking advantage of a comprehensive diet quality assessment tool, the HEI-2010, in a national sample of Mexican Americans, the present study aimed to evaluate diet quality and examine the relationship between diet quality and central obesity among Mexican-American men and women.

Methods

Study design and data source

The current study utilized a cross-sectional design based on data from the continuous National Health and Nutrition Examination Survey (NHANES), cycle 1999–2000 to cycle 2010–2012. The continuous NHANES is a complex, multistage probability sample of US non-institutionalized civilians that started in 1999. Each two-year survey cycle examines a nationally representative sample of approximately 10 000 persons and collects information on the health and nutritional status of adults and children. Some subgroups, including Mexican Americans, are oversampled, so that the reliability and precision of the estimated health status indicators for these groups are ensured (detailed information on NHANES is described elsewhere)[30]. About 72 000 (n 71 916) individuals completed an in-person home interview in the seven study cycles. Just under 69 000 (n 68 705) completed an interview and an examination in a mobile examination centre, among which 7096 were Mexican-American adults aged 20 years or older. After removing 249 Mexican-American adults with missing dietary data or waist circumference measurement, a total of 6847 individuals with reliable dietary recall status and non-pregnancy status were included in the present study (see online supplementary material, Supplemental Fig. 1). Data from the US Department of Agriculture's Food Pattern Equivalents Database (FPED) were obtained to translate NHANES dietary data into equivalent servings of the major food groups and subgroups according to the HEI-2010[31]. The National Center for Health Statistics' Research Ethics Review Board approved NHANES and informed consent was obtained from all participants[30].

Measures

The primary study outcome, central obesity, was categorized based on physical exam information from NHANES. Central obesity was defined as a waist circumference of ≥88 cm for women and ≥102 cm for men[32,33]. Dietary intake data were obtained from the NHANES in-person 24 h recall interview[30]. This information included names of foods, times they were consumed, type of meal or snack, and where the food was consumed. Instructions were provided to the participants orally in English and/or

Spanish. Measurement aids and visuals were used to quantify the foods and beverages that were reported. The dietary assessment was carried out by a trained interviewer in a mobile examination centre[30]. FPED was used to examine consumption in terms of food group equivalent servings. FPED translated dietary recall data into equivalent servings of the major food groups and subgroups. Mixed foods were disaggregated (i.e. broken down into their ingredients), with solid fats and added sugars counted separately[11]. Diet quality was calculated by using the HEI-2010. Briefly, the HEI-2010 was designed to evaluate compliance with the key diet-related recommendations of the 2010 Dietary Guidelines for Americans. The HEI-2010 was summed to a maximum total score of 100. HEI-2010 scores were density-based; that is, the amount of a dietary component of interest consumed (i.e. a food group or nutrient) was divided by total energy and multiplied by 1000 or expressed as a percentage of energy[11]. The density approach measures diet quality, which is a mix of food, rather than diet quantity[11].

Sociodemographic covariates included gender, age (20–40, 41–60 or >60 years), education (less than high school, high school or equivalent, or more than high school), marital status (yes or no) and poverty-to-income ratio (PIR < 1, 1 ≤ PIR < 3 or PIR ≥ 3), smoking status (never, former or current) and alcohol drinking status (never, former or current). Insurance coverage was categorized into: (i) public insurance including Medicare, Medicaid and other forms of government insurance; (ii) private insurance; and (iii) no health insurance. Acculturation was constructed as an acculturation score, which was based on three proxy measures: (i) country of birth; (ii) language spoken at home; and (iii) length of time in the USA. Combining country of birth and length of time in the USA, a score of 0–3 was assigned based on four categories (3 = US-born; 2 = foreign-born and lived in the USA for ≥20 years; 1 = foreign-born and lived in the USA for 10–19 years; 0 = foreign-born and lived in the USA for <10 years). A score of 0–2 was assigned to the language spoken at home (2 = English only or pro-English; 1 = both English and Spanish equally; 0 = Spanish or pro-Spanish). These scores were summed to yield a total acculturation score, ranging from 0 (least acculturated) to 5 (most acculturated). This scale was based on one used in a previous study of Hispanic and Chinese populations[34]. The variable of physical activity was examined by using the physical activity questionnaire items employed in NHANES. Participants were asked their engagement in moderate-to-vigorous physical activity during the past 30 d related to transportation, household/domestic tasks and leisure-time activities. Their responses were translated into minutes of moderate-to-vigorous physical activity per week. Each participant's combined weekly duration of moderate-to-vigorous physical activity was grouped into one of two categories (<150 or ≥150 min/week) based upon their achievement of current activity guidelines[35]. Lastly, data release number (SDDSRVRY) was taken into account in the analysis to adjust for potential different distributions of sampled populations in different survey cycles.

Analyses

All statistical analyses for the study were conducted using the statistical software package SAS version 9.4. Multivariable logistic regressions were conducted to investigate the association between HEI-2010 total score and central obesity, as well as the associations between HEI-2010 component scores and central obesity. Considering the complexity of the sampling design, survey-related commands (e.g. PROC SURVEYMEANS) were employed to adjust for the complex survey design effect. In particular, the primary sampling unit and stratum for each observation were taken into account in the analysis[30].

Results

Table 1 presents sociodemographic and behavioural characteristics, as well as central obesity status of Mexican Americans. The mean acculturation score was 2·4 for Mexican Americans in NHANES cycles 1999–2000 to 2010–2012. Almost 51 % of participants were centrally obese. In gender-specific analyses, women appeared less likely to be current smokers (12 *v.* 27 %) and current drinkers (53 *v.* 79 %), but more likely to achieve the Physical Activity Guidelines for Americans (63 *v.* 52 %). However, in comparison to men, women were more likely to be centrally obese (68 *v.* 36 %).

HEI-2010 scores by gender are presented in Table 2. The mean HEI-2010 total score for all Mexican Americans in NHANES cycles 1999–2000 to 2010–2012 was 50. Mexican-American women appeared have better overall diet quality (HEI-2010 total score: 51·1 *v.* 48·4, $P < 0·001$) than their male counterparts. Compared with men, women also had higher scores across most HEI-2010 component categories, except in the categories of greens and beans (2·0 *v.* 2·1, $P < 0·001$), total proteins (4·3 *v.* 4·5, $P < 0·001$) and fatty acids (5·1 *v.* 5·2, $P < 0·001$), where women scored lower than their male counterparts. Mexican-American women had higher mean HEI-2010 total scores than Mexican-American men (Fig. 1).

Table 3 presents findings from multivariable logistic regression models assessing the relationship between HEI-2010 scores and central obesity. A higher HEI-2010 total score was significantly associated with lower odds of central obesity (OR = 0·98; 95 % CI 0·98, 1·00) in Mexican-American men, but not in women (OR = 1·00; 95 % CI 0·99, 1·01). Among all Mexican Americans, a one-unit higher score of total fruit and sodium was associated with 4 % (OR = 0·96; 95 % CI 0·93, 0·99) and 2 % (OR = 0·98; 95 % CI 0·96, 0·99) lower odds of central obesity, respectively (note that a higher sodium score indicates a lower level of

Table 1 Characteristics of Mexican-American men and women aged ≥20 years (*n* 6847), National Health and Nutrition Examination Survey (NHANES) 1999–2012

	All		Men		Women	
	n	%	*n*	%	*n*	%
Age (years)						
20–40	3096	61·5	1382	63·6	1590	59·2
41–60	1948	29·0	941	28·5	940	29·6
>60	1803	9·5	788	8·0	899	11·2
Education						
Less than high school	4047	53·0	1896	55·1	1954	50·6
High school or equivalent	1235	20·7	563	21·4	622	20·0
More than high school	1550	26·3	649	23·4	844	29·4
Income						
PIR < 1·0†	1929	31·3	830	29·1	1026	33·7
1 ≤ PIR < 3	2039	47·8	1413	49·9	1422	45·5
PIR ≥ 3	1550	20·9	567	21·9	587	20·8
Marital status						
Married	3971	56·6	1953	58·5	1849	54·5
Health insurance						
No	2944	51·1	1451	54·9	1387	46·9
Public	1544	14·0	573	9·9	888	18·6
Private	2257	34·9	1052	35·2	1106	34·5
Smoking						
Non-smoker	4120	61·5	1391	49·4	2539	74·9
Former	1494	18·6	923	23·5	506	13·2
Current	1224	19·9	795	27·1	378	12·0
Alcohol drinking						
Non-drinker	997	15·4	111	4·4	886	27·6
Former	1164	17·7	555	16·5	609	19·2
Current	3437	66·9	2001	79·2	1436	53·2
Physical activity						
Met PAGA (≥150 min/week)‡	4084	56·7	1703	51·5	2192	62·5
Central obesity§	3490	50·9	1127	35·5	2363	68·1
	Mean	SE	Mean	SE	Mean	SE
Acculturation index (range 0–5)‖	2·4	0·1	2·3	0·1	2·6	0·1

Missing data: age, *n* 307; education, *n* 319; PIR, *n* 1005; married, *n* 430; insurance status, *n* 390; physical activity, *n* 1249; smoking, *n* 315.
†Poverty-to-income ratio.
‡2008 Physical Activity Guidelines for Americans; moderate-intensity physical activity of ≥150 min/week is needed.
§Central obesity: waist circumference ≥102 cm in men; ≥88 cm in women.
‖Acculturation index is a score ranging from 0 to 5 (0 is the lowest acculturation and 5 is the highest acculturation). The index is derived from information of length of stay, nativity and language spoken at home.

Table 2 Healthy Eating Index-2010 (HEI-2010) total scores and component scores in Mexican-American men and women aged ≥20 years (*n* 6847), National Health and Nutrition Examination Survey (NHANES) 1999–2012

	All		Men		Women		
	Mean	SE	Mean	SE	Mean	SE	*P* value†
HEI-2010 total score (0–100)‡	49·7	0·3	48·4	0·3	51·1	0·4	**
Total vegetables (0–5)	3·5	0·0	3·4	0·0	3·6	0·0	**
Greens & beans (0–5)	2·1	0·0	2·1	0·0	2·0	0·1	**
Total fruit (0–5)	2·1	0·0	1·9	0·1	2·4	0·0	**
Whole fruit (0–5)	2·0	0·0	1·8	0·1	2·2	0·1	**
Whole grains (0–10)	1·4	0·0	1·1	0·1	1·6	0·1	**
Total dairy (0–10)	4·7	0·1	4·2	0·1	5·2	0·1	**
Total proteins (0–5)	4·4	0·0	4·5	0·0	4·3	0·0	**
Seafood & plant proteins (0–5)	2·0	0·0	1·9	0·1	2·0	0·0	*
Fatty acids (0–10)	5·2	0·1	5·2	0·1	5·1	0·1	
Sodium (0–10)	5·4	0·1	4·5	0·1	5·2	0·1	**
Refined grains (0–10)	4·6	0·1	4·6	0·1	4·7	0·1	
Empty calories (0–20)§	12·4	0·1	12·1	0·1	12·8	0·2	**

*$P < 0·05$, **$P < 0·001$.
†*P* values are based on *t* tests for differences in scores between men and women.
‡Score range for each HEI-2010 category is given in parentheses; higher score means better quality.
§Empty calories are from solid fats, alcohol and added sugars.

intake). However, a higher score of total proteins was associated with higher odds of central obesity (OR = 1·08; 95 % CI 1·00, 1·16). When stratifying by gender, a higher whole fruit score was significantly associated with lower odds of central obesity in men (OR = 0·95; 95 % CI 0·90, 0·99) but not in women. A higher sodium score was associated with lower odds of central obesity (OR = 0·97; 95 % CI 0·94, 0·99) only in men.

Discussion

The present study found that Mexican-American women in general had better diet quality than Mexican-American men. This result is consistent with the finding in the general US adult population[36]. The current study also suggested that a better HEI-2010 total score, indicating a better overall diet quality, was associated with a lower chance of central obesity among Mexican-American men. However, in women, the association was not significant. Some obesity studies have used gender-mixed samples or women-only samples[8,37], and few studies have explored in detail the gender difference in diet quality and its association with central obesity among Mexican Americans. The lack of significance for HEI-2010 total score in Mexican-American women may be due to their higher HEI-2010 total scores than men. A higher HEI-2010 score may reflect women's greater emphasis on a healthy diet[23], which may have resulted in a greater reporting bias in women than in men[16]. Another reason for this gender difference regarding diet quality and its effects on central obesity may be that immigrant men consume fast food more frequently than their female counterparts, possibly due to their preference of its ease and convenience, and their cooking and time limitations[38]. Beyond behaviour, basic biology may play a role. Biologically, men tend to store body fat in the abdominal region, whereas women tend to store fat in the lower extremities[39]. This biological difference in fat distribution between genders may also potentially explain the significant association between overall diet quality and central obesity among Mexican-American men.

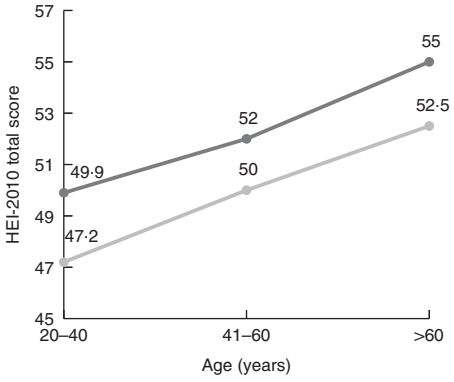

Fig. 1 Mean Healthy Eating Index-2010 (HEI-2010) total score, by gender (—●—, men; —●—, women) and age, among Mexican-American men and women aged ≥20 years (*n* 6847), National Health and Nutrition Examination Survey (NHANES) 1999–2012

In addition to overall diet quality, the present study also explored independent effects of fruits, proteins and sodium on central obesity. Even though few studies have examined the relationship between these dietary components and central obesity using the HEI measurement, some reported that increased intake of fruits has inverse relationships to anthropometric measures[3,15,40]. Fruits, which contain little cholesterol but are rich in vitamins, minerals and fibres, are essential for a healthy weight. Fruits also provide the body with phytochemicals including β-carotene, lutein and

Table 3 Logistic regression results of the associations between Healthy Eating Index-2010 (HEI-2010) total scores and component scores and central obesity in Mexican-American men and women aged ≥20 years (*n* 6847), National Health and Nutrition Examination Survey (NHANES) 1999–2012

	Central obesity†,‡					
	All		Men		Women	
	OR	95 % CI	OR	95 % CI	OR	95 % CI
HEI-2010 total score	0·99	0·99, 1·00	0·98*	0·98, 1·00	1·00	0·99, 1·01
Total vegetables	0·99	0·95, 1·05	0·99	0·93, 1·07	1·01	0·95, 1·07
Greens & beans	0·99	0·97, 1·03	0·97	0·92, 1·02	1·03	0·98, 1·07
Total fruit	0·96*	0·93, 0·99	0·95	0·90, 1·00	0·96	0·91, 1·01
Whole fruit	0·97	0·94, 1·00	0·95*	0·90, 0·99	0·99	0·95, 1·03
Whole grains	0·99	0·96, 1·03	0·99	0·95, 1·04	0·99	0·95, 1·04
Total dairy	0·99	0·97, 1·02	1·00	0·97, 1·03	0·98	0·95, 1·01
Total proteins	1·08*	1·00, 1·16	1·06	0·96, 1·18	1·09	1·00, 1·19
Seafood & plant proteins	1·00	0·97, 1·04	0·98	0·94, 1·03	1·02	0·97, 1·07
Fatty acids	1·01	0·99, 1·03	0·99	0·97, 1·02	1·03	0·99, 1·06
Sodium§	0·98*	0·96, 0·99	0·97*	0·94, 0·99	0·97	0·94, 1·01
Refined grains§	1·00	0·99, 1·02	1·00	0·98, 1·03	0·99	0·97, 1·02
Empty calories§	1·00	0·99, 1·01	0·99	0·97, 1·01	1·02	0·99, 1·03

*$P < 0·05$.
†Odds of central obesity in Mexican Americans with a lower HEI-2010 score relative to odds of central obesity among individuals with higher HEI-2010 score.
‡Adjusted for age, education, income, marriage status, insurance status, acculturation, smoking status and alcohol drinking status.
§Sodium, refined grains and empty calories are 'moderation' components, where a higher score indicates a lower level of intake.

lycopene, which promote good health and reduce the risk for central obesity[41]. The beneficial effects of fruit intake may support the association between fruit score and central obesity found in the current study.

With respect to the finding concerning the relationship between sodium intake and the outcome, the current study showed that a higher sodium score, which reflects a lower level of intake, was associated with lower odds of central obesity in Mexican Americans. Moderate sodium intake is known to be effective in protecting cardiovascular health[42–45] and preventing and managing diabetes[46,47]. Researchers have studied a close link between sodium intake and weight gain. According to Karppanen and Mervaala[45], a high sodium intake obligatorily produces a progressive increase in thirst. The progressive increase in average intake of salt explains the observed concomitant increase in intake of sugar-sweetened or alcoholic beverages, which are sources of excessive energy intake[48–50]. Perhaps the high sodium intake together with intake of unhealthy beverages may help to explain the inverse relationship between sodium score (i.e. a higher score indicates a lower level of intake) and central obesity observed in Mexican Americans. Additionally, previous work has suggested that excessive sodium intake is often correlated with frequency of eating out and consumption of processed packaged foods and salty snacks[8,51]. Many Mexican Americans rely on ready-made processed foods and eating out because of the fast-paced life in the USA and the pressure to integrate into American society by eating American-style fast food[12,52,53]. According to the US Centers for Disease Control and Prevention, more than 75 % of the sodium in the average American diet comes from salt added to processed foods[54], which usually are energy-dense and a possible cause of obesity[55,56]. Salt is often used to preserve foods and modify flavour, and is included in additives that affect the texture or colour of foods[55]. When the consumption of processed foods and occasions of eating out increase, sodium intake is likely to increase and so too is the chance of gaining weight[54,55]. Perhaps the correlation between sodium intake and consumption of processed or restaurant foods can serve as another explanation for the relationship between sodium score and central obesity in Mexican Americans[51–56].

The present study results also indicated that a higher score of total proteins, indicating a higher level of intake, was associated with increased odds of central obesity. Similar results regarding the association between protein intake and weight gain have been shown before[16,57,58]. One study assessed the association between diet quality measured by the HEI-2010 and body weight; it found that a high score of total proteins is associated with an increased risk for obesity[16]. The association was determined in a large US sample[57], as well as in an all-women sample from the Framingham nutrition studies[58]. A potential explanation for the positive association between a higher level of protein intake and obesity outcomes is that there is a positive correlation between fat and total protein intake[16]. Meat or poultry may contribute a significant share of dietary protein for Mexican Americans[59]. The association between protein and central obesity is probably attributable to increased consumption of processed foods or red meat[60–62]; and it may be that these products are becoming a major source of proteins for Mexican Americans[59,62]. This places them at a higher risk for central obesity. Commercially prepared meats such as sandwich meats, bacon, salami or sausage are not only notoriously high in sodium but also high in fat[63]. Processed meats are made by grinding and combining fatty cuts of meat and they can be a potent but overlooked source of saturated fat and energy[64]. A recent study showed that Mexican Americans follow a meat-oriented dietary pattern, which includes primarily processed meats, rather than the traditional plant-based Mexican diet that relies on legumes as a major source of protein[59]. These dietary habits, along with the epidemiological evidence that increased processed meat intake increases the risk of chronic disease[65,66], aid in understanding the association between the score of proteins and central obesity, and highlight the importance of promoting healthier protein alternatives such as plant-based protein foods.

Study limitations

The current study has several limitations. First of all, NHANES data are cross-sectional, which precluded examination of changes in diet quality and weight status in the cohort over time. Without a longitudinal design, associations can be assessed but evidence of a causal relationship between diet quality and central obesity cannot be established. Furthermore, the study was exclusively focused on Mexican Americans, so results may not be generalizable to other populations because of the variations within cultural practices and obesity risks across races/ethnicities. Additionally, it is possible that the study excluded some undocumented immigrants. This group of people may be less likely to participate in NHANES questionnaires or physical examinations due to fear of exposing their illegal status.

Measurements for some study variables may have incorporated errors. Although more exact methods exist for measuring visceral adipose tissue accumulation (e.g. MRI and computerized tomography), NHANES did not employ these exact methods. Previous studies have shown that waist circumference has a strong association with visceral adiposity[67] and it is therefore the recommended measure to estimate the risk of CVD and type 2 diabetes for many populations[68–72], including Mexican Americans.

Additionally, potential biases may exist in measuring diet. Under-reporting by participants is common in nutritional studies, especially among those who are overweight

or obese[73]. Thus, the potential bias towards the null resulting from under-reporting is acknowledged. Extreme dietary intake values were excluded from the current study. Additionally, some scholars argue that the discrete distributions within HEI scoring patterns may reduce its power as a predictor[74]. Some are also concerned that arbitrary choices made in scoring HEI components may hamper its ability to predict risks for chronic diseases[58,75]. In fact, the insignificant finding on the relationship between empty calories and central obesity may demonstrate this limitation. The HEI-2010 considers alcohol above a threshold level indicative of moderate drinking as empty calories. This approach does not directly address other potential positive and negative biological effects of alcohol, nor does it account for specific questions related to frequency of consumption and amounts consumed on drinking occasions[11]. Perhaps the poor sensitivity of the HEI-2010 empty calories score in predicting central obesity can be partially explained by the limited information on alcohol measurement. Therefore, when using the HEI-2010 to examine relationships between diet quality and health outcomes, additional considerations regarding alcohol may be warranted[11].

Study strengths

Despite the limitations, the study contributes to the literature by presenting national-scale evidence regarding the effect of diet quality on clinically validated central obesity among Mexican Americans. The current investigation utilizes a comprehensive measure of diet quality, which allows for an assessment of overall diet quality and major food group balances of Mexican Americans[47]. Most of the existing studies on diet have focused on specific nutrient components, such as fats and sugars, or on the consumption of individual food groups[8,9]. These nutritional outcomes have been critiqued as 'being overly reductionist, failing to account for how foods are eaten in combination as part of meals or cuisines', according to Park *et al.*[76]. Total food intake is a complex construct, which cannot be described or evaluated based on nutrients measured in isolation from one another. The HEI-2010 is able to measure consumption levels of food groups and nutrients concurrently, which is a superior approach in estimating dietary intake[77]. It is also worthy to note that the HEI-2010's utilization of the density approach (i.e. as a percentage of energy consumed) allows for characterization of intake levels while controlling for total energy intake[78], which is highly correlated with the quantity of foods consumed. This may further suggest the HEI-2010 is a better way to measure diet and to inform dietary modifications. Moreover, the study identified that specific aspects of diet, as indicated by HEI-2010 component scores, were related to central obesity. This may suggest particular areas for dietary interventions that are more targeted to the Mexican-American population. Additionally, a Mexican-American sample derived from a national survey data (i.e. NHANES) was used and gender-stratified analyses were conducted. The analyses accounted for survey design complexity and yielded estimates for the nation as a whole. Findings may assist with designing gender-specific and culturally relevant solutions to tackle obesity-related disparities among Mexican Americans.

Implications

The current study findings assist in the understanding of diet quality and central obesity in Mexican Americans by demonstrating their diet quality and how it contributes to the central obesity among them. These findings may lend insights for community-level dietary interventions and national-level policies aimed at reducing the high rates of central obesity and related health problems among Mexican Americans. Nutrition professionals should consider promoting whole fruits that are culturally appropriate, as well as introducing Western produce to the community. Additionally, promoting home cooking as a strategy for reducing sodium intake may be beneficial for Mexican Americans, especially for Mexican-American men who may consume more fast food and have poorer cooking skills than their female counterparts[79]. It is essential that enhancing the understanding of food labels, of nutritional merits of different foods and of food preparation methods be incorporated into the dietary interventions. A regulatory approach that supports the food industry in the reformulation of foods is recommended[80]. If these efforts were implemented, they would provide greater flexibility for meeting the sodium intake guideline when individuals consume commercially prepared foods. It is also suggested that other protein-containing foods may better replace meat and poultry, especially processed meat products. The HEI-2010 includes a separate category for seafood and plant-based proteins, which indicates the awareness of the potential detrimental effects of animal-based protein. Scholars have suggested that rather than relying on absolute protein intake, a ratio of total protein to seafood and plant proteins may be a better indicator for a healthy diet[16]. As for practice, nutrition professionals should encourage the intake of healthier protein alternatives, such as legumes and seafood. Also, cheese made with lower-fat milk, including Hispanic-style cheeses available in lower-fat varieties such as Queso Oaxaca and Queso Fresco, can also be a healthy protein source to be promoted in the community.

Conclusion

The present study showed that, in general, Mexican-American women appeared to have better diet quality than their male counterparts. The study also revealed that a better diet quality was associated with a lower chance of central obesity among Mexican Americans, especially in Mexican-American men. In particular, component scores of fruits and sodium were inversely related to central

obesity, but the score of total proteins was associated with higher odds of central obesity. To reduce the risks for central obesity in Mexican Americans, dietary interventions should focus on enhancing the diet quality, especially in the areas of fruit and healthy protein promotion as well as sodium reduction.

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Supplementary material

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